Claims

What we claim is:

1. An apparatus for enhancing a chemical reaction comprising:
(a) a chemical reactor for containing a liquid sample selected from the group including: a single component liquid; a multi-component liquid; and, a liquid continuous multi-phase system; and,
(b) two or more electrodes of any shape for applying to the liquid continuous sample an electric field with a carrying frequency greater than 100 kHz and less than 200 GHz and no limitation on the modulation of the electric field;
wherein, in use, the amplitude of the electric field is sufficient to induce dielectric breakdown or pre-breakdown conditions within the liquid continuous sample, which are necessary conditions for the present invention.

2. An apparatus for enhancing a chemical reaction according to claim 1 forming part of an electromagnetic resonant circuit.

3. A method of controlling a chemical reaction comprising the steps of:
a) providing to a chemical reactor a liquid continuous sample selected from the group including: a single component liquid; a multi-component liquid; and, a liquid continuous multi-phase system;
b) applying to the liquid continuous sample an electric field having a carrying frequency greater than 100 kHz and less than 200 GHz and no limitation on the modulation of the electric field, wherein the amplitude of the electric field is sufficient to cause at least one of a breakdown condition and a pre-breakdown condition within the liquid continuous sample;
c) detecting an indication of at least one of the breakdown condition and the pre-breakdown condition within the liquid continuous sample resulting from the applied electric field; and,
d) controlling the chemical process in dependence upon a feedback signal related to the indication of at least one of the breakdown condition and the pre-breakdown condition.

4. A method as defined in claim 3 wherein the frequency of the electric field is selected to be in resonance with a response frequency of at least one of a component and a phase of the liquid continuous sample.

5. A method as defined in claim 3 including the step of applying to the liquid continuous sample a second carrying frequency, the second carrying frequency in resonance with a response frequency of at least one of a second component and a second phase of the liquid continuous sample.

6. A method as defined in claim 3 including the step of applying to the liquid continuous sample an additional low frequency electric field within the industrial range of 50 Hz to 60 Hz.

7. A method as defined in claim 3 including the step of applying to the liquid continuous sample an additional DC electric field.

8. A method as defined in claim 3 including the step of applying to the liquid continuous sample an additional magnetic field.

9. A method as defined in claim 3 including the step of adding a chemical compound to the liquid continuous sample for enhancement of the chemical reaction.

10. A method as defined in claim 3 including the step of providing a flow of a gas through the liquid continuous sample, the gas being provided from a source external to the chemical reactor.

11. A method as defined in claim 3 including the step of affecting the temperature of the liquid continuous sample.

12. A method as defined in claim 3 including the step of separating at least one of a gaseous reaction product and a solid reaction product from the liquid continuous sample.

13. A method as defined in claim 3 wherein the liquid continuous sample is a toxic liquid for destruction within the chemical reactor absent combustion.

14. A method as defined in claim 3 wherein the liquid continuous sample is a petroleum product for upgrading within the chemical reactor.

15. A method as defined in claim 3 wherein the liquid continuous sample is a precursor for the production of chemical compounds for the chemical storage of renewable energy.

16. A method of controlling a chemical process involving a liquid continuous sample that behaves substantially as a dielectric when subject to an electric field having a carrying frequency below 60 Hz and exhibits an increased electric conductivity when subject to an electric field having a carrying frequency above 100 kHz, the method comprising the steps of:
a) providing the liquid continuous sample to a reactor having a reaction chamber for accommodating the liquid continuous sample;
b) applying an electric field across a region of the reaction chamber for causing an increase in specific conductivity of the liquid continuous sample; and,
c) detecting information related to the progress of the chemical process resulting from the increase in specific conductivity and at least one of a breakdown and pre-breakdown condition.

17. A method as defined in claim 16 comprising the step of:
d) controlling the chemical process in dependence upon the detected information.

18. A method as defined in claim 17 wherein the carrying frequency of the electric field is selected in dependence upon the dielectric properties of the liquid continuous sample.

19. A method as defined in claim 18 wherein the carrying frequency is selected from a range of frequencies between 100 kHz and 200 GHz.

20. A method as defined in claim 19 wherein a second other carrying frequency of the electric field is selected in dependence upon the dielectric properties of the liquid continuous sample to control a second other chemical reaction.

21. A method as defined in claim 19 wherein the step of controlling the chemical process comprises the step of adjusting at least one of a shape, duration, carrying frequency and amplitude of the electric field for inducing a dielectric pre-breakdown condition within the liquid continuous sample.

22. A method as defined in claim 19 wherein the step of controlling the chemical process comprises the step of adjusting at least one of a shape, duration, carrying frequency and amplitude of the electric field for inducing a dielectric breakdown condition within the liquid continuous sample.

23. A method as defined in claim 19 wherein the liquid continuous sample is one of a single component and a multi-component liquid continuous sample.

24. A method as defined in claim 23 wherein the liquid continuous sample is a liquid continuous multi-phase system.

25. A method as defined in claim 23 wherein the liquid continuous sample is a petroleum product.

26. An apparatus for enhancing a chemical reaction comprising:
(a) a reactor having a reaction chamber for accommodating a liquid sample therein;
(b) a first and a second electrode for applying to the liquid sample an electric field having an alternating current with a carrying frequency and an amplitude sufficient to cause at least one of a breakdown condition and a pre-breakdown condition within the liquid sample; and,
(c) an electrical controller for controlling the application of the electric field.

27. An apparatus as defined in claim 26 wherein, in use, the carrying frequency is higher than 100 kHz.

28. An apparatus as defined in claim 27 wherein, in use, the carrying frequency is selected from a range of frequencies between 100 kHz and 200 GHz.

29. An apparatus as defined in claim 26 comprising a sensor for detecting an indication of the at least one of the breakdown condition and the pre-breakdown condition and for providing a feedback control signal in dependence thereof.

30. An apparatus as defined in claim 29 comprising an electrical controller for controlling the application of the electric field in dependence upon the feedback control signal.

31. An apparatus as defined in claim 30 wherein the electrical controller comprises a feedback system for modifying at least one of a shape, carrying frequency, amplitude and duration of the applied electric field for enhancing the reaction.

32. An apparatus as defined in claim 30 wherein the electrical controller comprises a feedback system for modifying at least one of a temperature, flow rate, and conductivity of the liquid sample for enhancing the reaction.

33. An apparatus as defined in claim 26 wherein at least one of the first and second electrodes are movable for selectively modifying the amplitude of the electric field.

34. An apparatus as defined in claim 33 wherein at least one of the first and second electrodes are moveable for modifying the amount of the liquid sample therebetween.

35. An apparatus as defined in claim 26 comprising a first cylinder and a second cylinder, the first and second cylinders coaxial and forming a cavity corresponding to the reaction chamber therebetween.

36. An apparatus as defined in claim 35 wherein the first cylinder comprises the first electrode and the second cylinder comprises the second electrode.

37. An apparatus as defined in claim 26 comprising a temperature sensor for providing an indication of a temperature within the reactor.

38. An apparatus as defined in claim 26 comprising a gas flow meter for providing an indication of at least one of a presence or quantity of at least a gas within the reactor.

39. An apparatus as defined in claim 26 comprising a heat source for affecting the temperature of the liquid sample being accommodated within the reaction chamber.

40. An apparatus as defined in claim 26 wherein the reaction chamber includes a gas inlet and a gas outlet for providing, in use, a flow of a predetermined gas therebetween, the gas inlet in fluid communication with a source of the predetermined gas.

41. An apparatus as defined in claim 30 wherein the sensor is an acoustic sensor for providing an indication of the pre-breakdown condition.

42. An apparatus as defined in claim 30 wherein the electrical controller comprises a feedback system for modifying at least one of a shape, carrying frequency, amplitude and duration of the applied electric field for enhancing the reaction.

43. An apparatus as defined in claim 30 wherein the electrical controller comprises a feedback system for modifying at least one of a temperature, flow rate, and conductivity of the liquid sample for enhancing the reaction.

44. An apparatus for enhancing a chemical reaction comprising:
(a) a reactor having a reaction chamber for accommodating a liquid sample therein;

(b) a first and a second electrode for applying to the liquid sample an electric field having an alternating current with a carrying frequency and an amplitude sufficient to cause at least one of a breakdown condition and a pre-breakdown condition within the liquid sample;
(c) a sensor for detecting an indication of the at least one of the breakdown condition and the pre-breakdown condition and for providing a feedback control signal in dependence thereof; and,
(d) an electrical controller for controlling the application of the electric field in dependence upon the feedback control signal.

45. An apparatus as defined in claim 44 wherein, in use, the carrying frequency is higher than 100 kHz.

46. An apparatus as defined in claim 45 wherein, in use, the carrying frequency is selected from a range of frequencies between 100 kHz and 200 GHz.

47. An apparatus as defined in claim 44 wherein the sensor is an acoustic sensor for providing an indication of the pre-breakdown condition.

48. An apparatus as defined in claim 44 comprising a temperature sensor for providing an indication of a temperature within the reactor.

49. An apparatus as defined in claim 44 comprising a gas flow meter for providing an indication of at least one of a presence or quantity of at least a gas within the reactor.

50. An apparatus as defined in claim 44 wherein the electrical controller comprises a feedback system for modifying at least one of a shape, carrying frequency, amplitude and duration of the applied electric field for enhancing the reaction.

51. An apparatus as defined in claim 44 wherein the electrical controller comprises a feedback system for modifying at least one of a temperature, flow rate, and conductivity of the liquid sample for enhancing the reaction.

52. A method of controlling a chemical reaction comprising the steps of:
a) providing a liquid sample to a reactor having a reaction chamber for accommodating the liquid sample therein;
b) applying to the liquid sample an electric field having a carrying frequency and an amplitude sufficient to cause at least one of a breakdown condition and a pre-breakdown condition within the liquid sample;
c) detecting an indication of at least one of the breakdown condition and the pre-breakdown condition within the liquid sample resulting from the applied electric field; and,
d) controlling the chemical process in dependence upon a feedback signal related to the indication of at least one of the breakdown condition and the pre-breakdown condition.

53. A method as defined in claim 52 wherein the carrying frequency is higher than 100 kHz.

54. A method as defined in claim 53 wherein the carrying frequency is selected from a range of frequencies between 100 kHz and 200 GHz.

55. A method as defined in claim 54 wherein the carrying frequency of the electric field is selected in dependence upon the dielectric properties of the liquid sample.

56. A method as defined in claim 55 wherein a second other carrying frequency of the electric field is selected in dependence upon the dielectric properties of the liquid sample to control a second other chemical reaction.

57. A method as defined in claim 55 wherein the step of applying the electric field includes the step of adjusting at least one of a shape, duration, carrying frequency and amplitude of the electric field for inducing a dielectric pre-breakdown condition within the liquid sample.

58. A method as defined in claim 55 wherein the step of applying the electric field includes the step of adjusting at least one of a shape, duration, carrying frequency and amplitude of the electric field for inducing a dielectric breakdown condition within the liquid sample.

59. A method as defined in claim 55 wherein the step of applying the electric field includes the step of adjusting at least one of a shape, duration, carrying frequency and amplitude of the electric field for providing resonant conditions under which a reaction rate of the chemical reaction is increased.

60. A method as defined in claim 52 wherein the liquid sample is one of a single component and a multi-component liquid sample.

61. A method as defined in claim 60 wherein the liquid sample is a liquid continuous multi-phase system.

62. A method as defined in claim 60 wherein the liquid sample is a petroleum product.

63. A method as defined in claim 60 wherein the liquid sample is selected from liquid samples that behave substantially as a dielectric when the electric field is below 60 Hz and exhibits an increased electric conductivity when the electric field is above 100 kHz.

64. A method as defined in claim 63 wherein the step of applying an electric field comprises the step of providing a first electrode and a second electrode.

65. A method as defined in claim 59 comprising the step of providing an acoustic sensor for detecting an indication of the pre-breakdown condition.

66. A method as defined in claim 59 comprising the step of providing a temperature sensor for detecting a temperature within the reactor.

67. A method as defined in claim 66 comprising the step of increasing the temperature of the liquid sample within the reactor.

68. A method as defined in claim 66 comprising the step of providing a gas flow meter for detecting at least one of the presence and amount of at least a gas within the reactor.

69. A method as defined in claim 68 comprising the step of providing a flow of a predetermined gas within the reaction chamber.